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THE MIDWEST STORM OF NOVEMBER 11, 1940

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[Weather Bureau, Chicago, Ill., April 1941]

On the morning of November 7, 1940, the Tacoma Narrows bridge collapsed as a result of high winds associated with a deep low-pressure area centered approximately 150 miles west of Tatoosh, Wash. Four days later, a secondary disturbance which had developed inland and moved southeastward, crossing the Rocky Mountains, then curving eastward over the southern Great Plains, passed north-northeastward across the extreme Upper Mississippi Valley and wrought great destruction, principally in the North-Central States and over the Upper Great Lakes Region. This was one of the worst storms, in respect to intensity, and amount and extent of damage, ever to strike the North-Central area. It is frequently referred to as the "Armistice Day storm" because of the fact that it developed so rapidly and caused such havoc on that day.

The first part of this report deals with the meteorological aspects of the storm, and the second describes the destruc-

tion resulting from the gales, heavy snow, and cold wave accompanying the disturbance.

METEOROLOGICAL ASPECTS

On November 8, 1940, the cyclonic disturbance which had caused gales the day before along the coast was still located about 150 miles west of the northern coast of Washington and was steadily filling. Pressure was falling, however, over the interior of the far Northwest, and by 1830 C. S. T. the lowest sea-level barometer reading reported was in extreme west-central Idaho. Figure 1 shows the successive 6-hourly positions of the center of this secondary cyclone, which moved as indicated above and reached south-central Colorado by 0030 C. S. T. November 10. The locations of the center as given in and west of the mountains are the points of approximate barometric minima at the respective 6-hourly observation

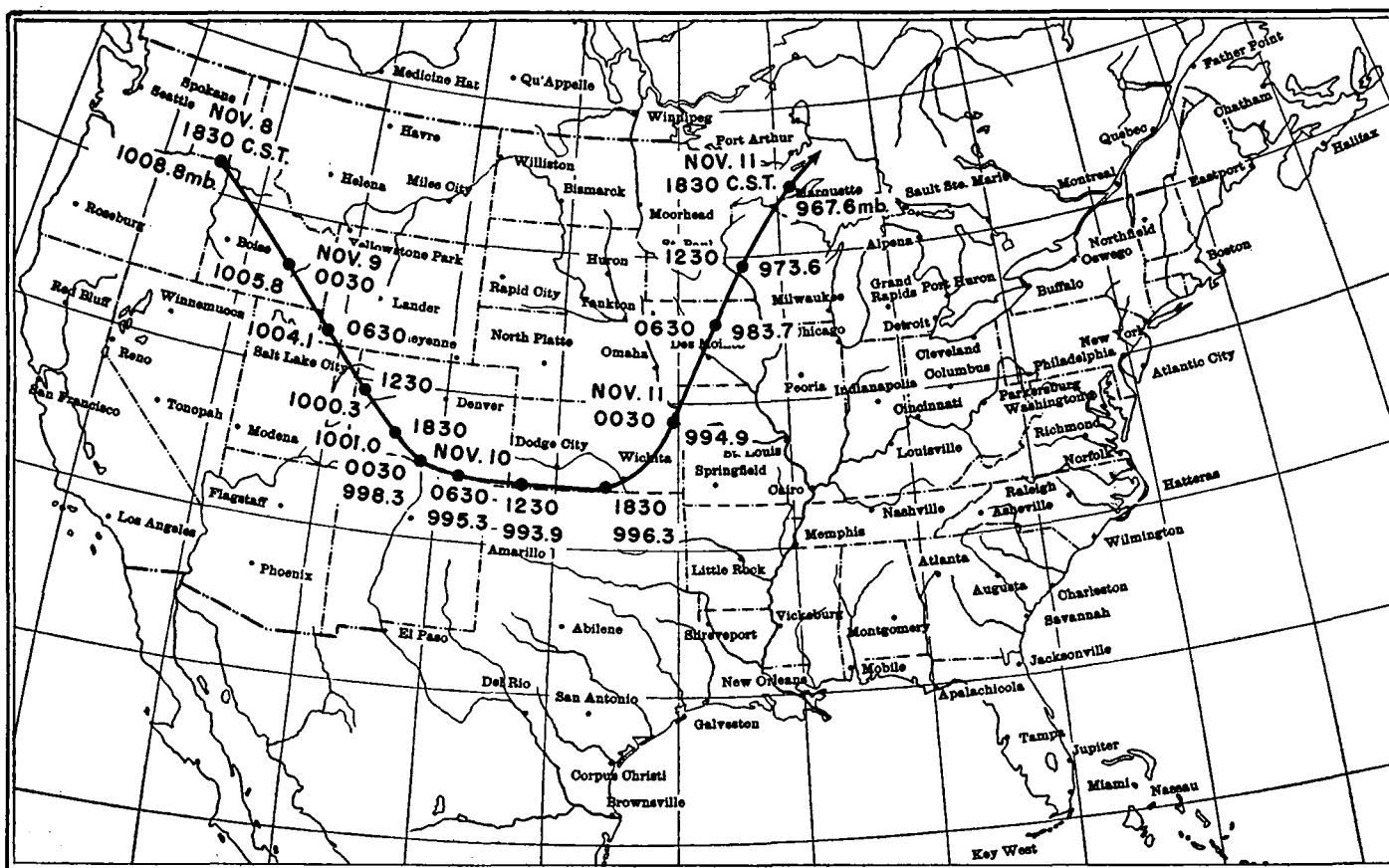


FIGURE 1.—Location of the cyclone center, and the lowest pressure reported, at 6-hour intervals from November 8–11, 1940.

periods. The pressure given is, in each case, the lowest reading reported in the vicinity of the center. While these positions are not coincident with those at a higher level, say at five thousand feet, where the barometric and wind patterns are less influenced by mountainous terrain, their exact locations are not important at this early stage of development.

At 0030 C. S. T., November 10, the arctic front (as distinguished from the polar front) extended in a trough from Colorado eastward across northern Kansas, thence northeastward to a filling wave over north-central Iowa, and on northeastward over the eastern portion of Lake Superior. A mass of cold polar air covered the region north of this front, extending far northwestward over Canada. Figure 2 shows temperature-height curves for Oklahoma City and Bismarck, approximately 250 miles south, and 450 miles north, respectively, of the surface front which at this time separated modified polar air to the south from the fresh supply of polar air to the north. The striking difference in the air masses above the two

stations is at once apparent, particularly the difference of approximately 20° C. in temperature at lower levels and 15° C. at higher elevations. At the same time, Brownsville, Tex., was located in tropical maritime air, the polar front being practically stationary and extending in an east-west direction over the central portions of Louisiana and East Texas. The isentropic chart for the potential temperature surface 298° at this time (not reproduced here) shows a broad flow of moist air from the West Gulf region north-northeastward over the middle Mississippi Valley, while modified polar pacific air was flowing northeastward over the area to the west of the moist tongue above the relatively shallow layer of polar air at lower levels.

During the day on November 10, the cyclone moved almost due eastward from the vicinity of Trinidad, Colo., and at 1830 C. S. T. was centered between Waynoka, Okla. and Wichita, Kans. The lowest pressure reported at this time was slightly higher than the minimum reported at the 0630 and 1230 observations. Figure 3 shows a section of the synoptic map based upon the 1830 C. S. T.

ADIABATIC CHART

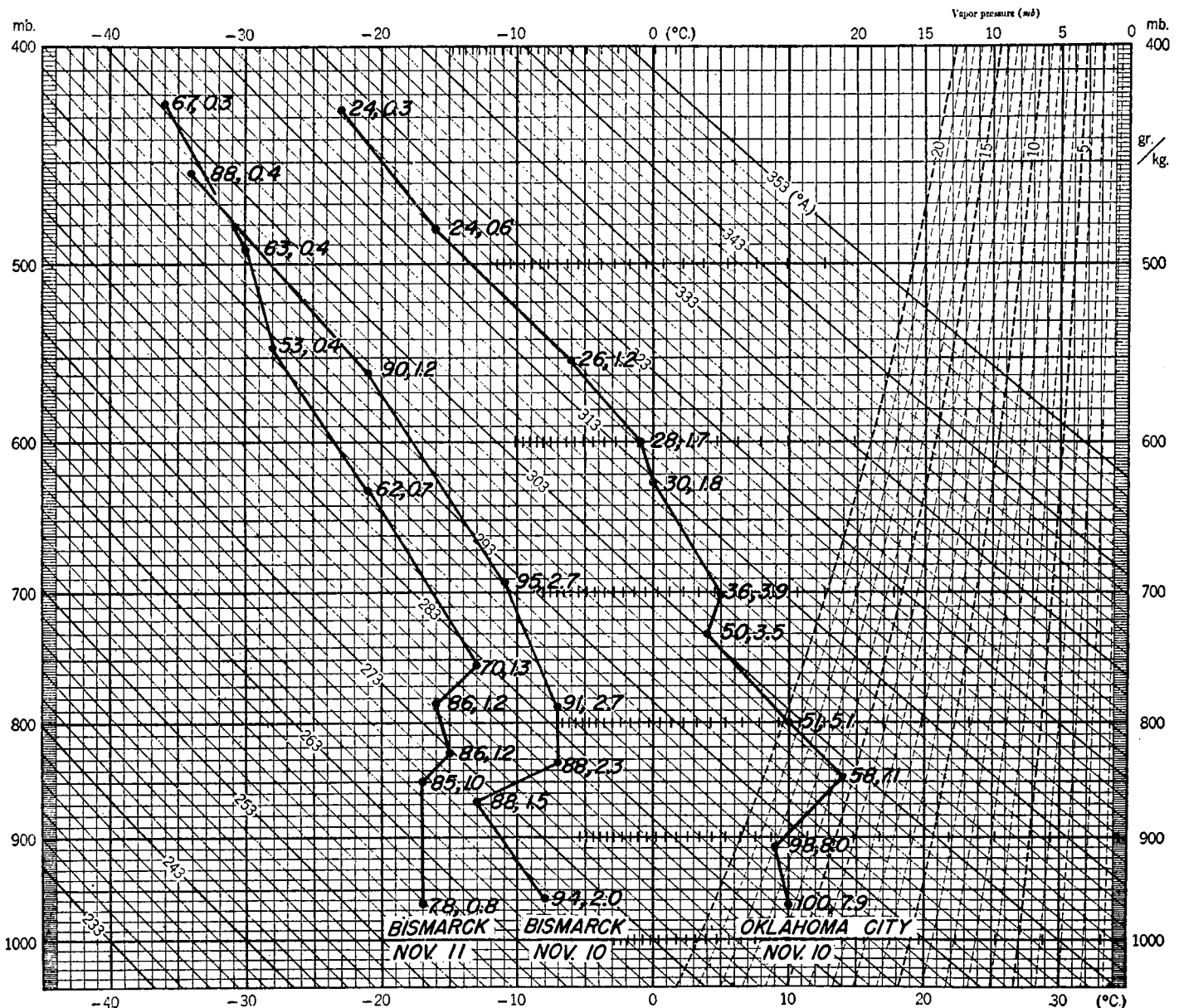


FIGURE 2.—Pressure-Height curves for Oklahoma City November 10, and Bismarck November 10 and 11, 1940.

observations. The warm front (a section of the polar front which had previously moved southward and become stationary over the West Gulf States) had moved northward into southern Arkansas and northeastern Texas. The cold front separating the tropical air from the polar pacific air mass extended southward from the cyclone center to north-central Texas and thence southwestward to the Rio Grande River. The arctic front was then being swept southward over the Texas Panhandle. Pilot-balloon observations were sparse in the Southern Plains section on the evening of the 10th, but velocities of WSW 66 and SW 54 miles an hour were reported by Amarillo and Oklahoma City, respectively, at the 8,000-foot level.

During the following 6 hours, the storm center curved to the northward and started developing, and at 0030 C. S. T. November 11, was moving north-northeastward over extreme northeastern Kansas, following approximately the quasi-stationary front that lay in the trough extending in that direction. By this time, the two cold fronts had been swept around to the positions shown in figure 4, and the western end of the warm front had been displaced northward to northeastern Arkansas. The stage was then set for the very rapid intensification of the storm which occurred in the ensuing 18 hours. A broad current of moist tropical air was flowing up the Mississippi Valley and intensely cold (for so early in the season)

polar air was sweeping southward over the Plains States. Figure 2 shows the cooling, due to advection, that had occurred during the preceding 24 hours in the lower five kilometers at Bismarck. Figure 8 shows a cross section through the atmosphere from Ely, Nev., to Joliet, Ill., at approximately 1 a. m. C. S. T.

An interesting feature of the upper-air structure is shown by radiosonde observations made at Omaha and Joliet on November 11 compared with the ones made the day before. The tropopause at Omaha lowered from 12.2 to 11.0 km. during the 24-hour period, with a corresponding rise of 5° C. in temperature. At Joliet, several hundred miles to the east of the storm center, the tropopause was lifted from 11.2 to 13.3 km. in the same 24 hours and the temperature decreased from minus 56° C. to minus 70° C. at the tropopause. These results might have been anticipated from a consideration of the results of the work of J. Bjerknes and others on the structure and changes in the tropopause and the relation of the tropopause to waves on the polar front. Whether the lifting of the tropopause at Joliet was due solely to advection of the higher tropopause to the south, or partially to convergence in the upper troposphere as a result of air rising within the low-pressure system and flowing out at high levels, is not certain.

The lowest pressure at 10,000 feet, reported in the early morning of November 11, was at Omaha, as might have

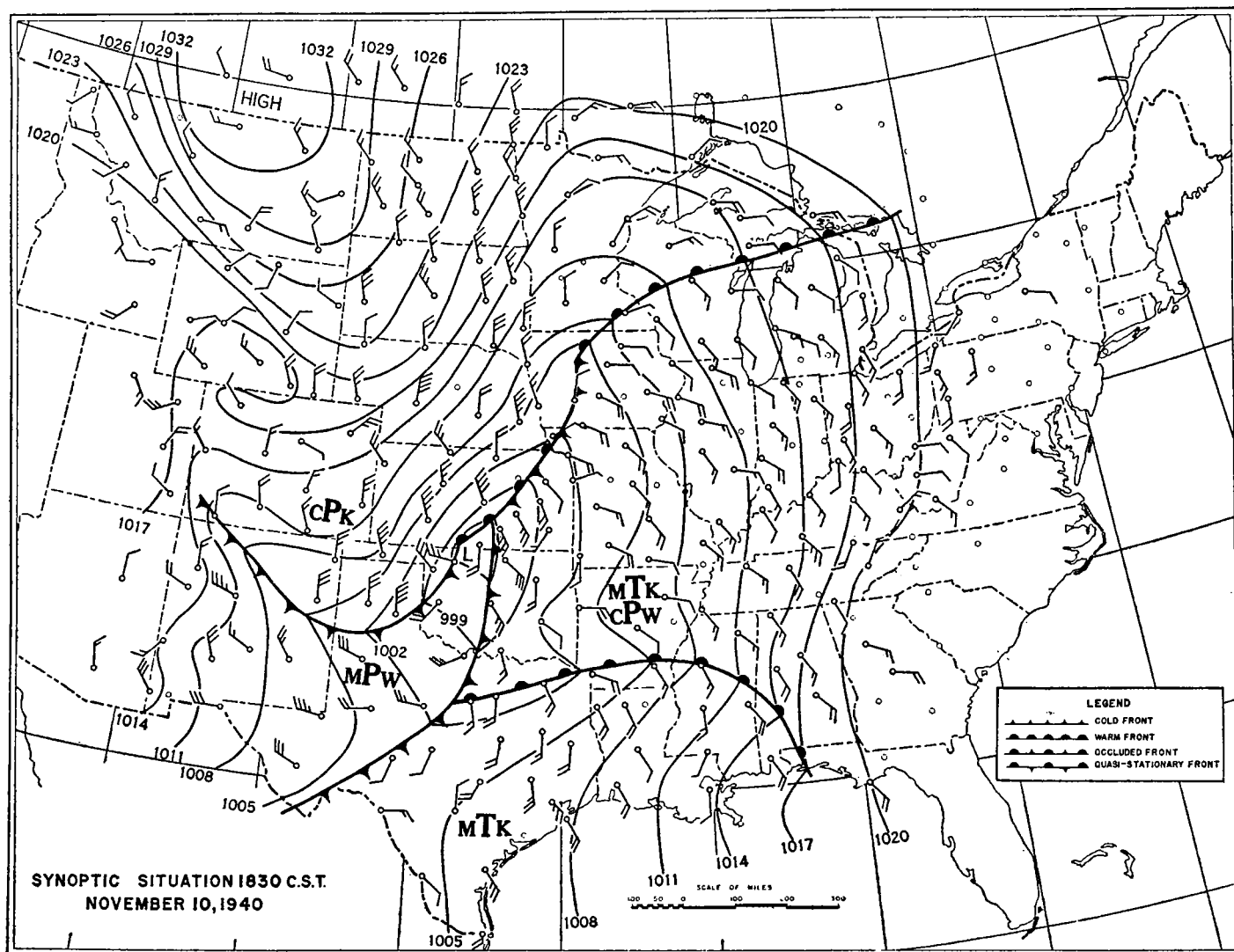


FIGURE 3.—Synoptic situation 1830 C. S. T., November 10, 1940.

been anticipated from the position of the surface center. Some observations on pressure changes at various levels will be discussed in a following paragraph.

By 0630 C. S. T. the cyclone center had moved to the vicinity of Iowa Falls, Iowa. Figure 5 shows the synoptic situation prevailing at that time in the central portion of the United States. Pilot-balloon observations were sparse due to precipitation and low clouds, but strong winds at the 2,000-foot level were as indicated below:

	Miles per hour
Wichita.....	NW. 43
Dallas.....	NW. 52
Houston.....	NW. 54
Little Rock.....	W. 37
New Orleans.....	S. 52
Cincinnati.....	S. 44

At 6,000 feet, Little Rock reported a velocity of W. 63 m. p. h.

The 1230 C. S. T. map, figure 6, shows the center of the storm to be a short distance north of La Crosse, Wis. The cold fronts had maintained their separate identities and swept rapidly eastward, and at this time were moving at a rate in excess of 50 m. p. h.

Frontal passages at Chicago.—Table 1 gives the hourly wind data for November 11 at the Weather Bureau observ-

atory at the University of Chicago. The first, or polar-pacific front passed the station shortly after 9 a. m., when the wind shifted from SE. to SW. This frontal passage had been preceded by strong SE. winds which reached an extreme of 39 m. p. h. as shown by the Dines anemometer record, and was followed by SW. winds of approximately the same force. The second, or polar-continental, front passed the station shortly before 11:30 a. m. and was accompanied by an abrupt and rapid increase in wind velocity without any indicated change in direction at the observatory. Directions are recorded at that station, however, to only 8 points of the compass, and reports before and following the frontal passage at the Chicago airport station indicate that there was a shift from SSW. to SW. Also attending the passage of this front were severe thundersqualls, heavy rain, and, in some sections of the city, hail. In table 1, it will be noted, the extreme velocity according to the Dines recorder was 65 m. p. h. and the maximum velocity, sustained for 5 minutes, was 42 m. p. h. The *Chicago Tribune* reported that on the Tribune Tower "there were 5 minute periods averaging 57 miles an hour." The Tribune anemometer is approximately 470 feet above the street level, while that of the Weather Bureau is 131 feet above ground.

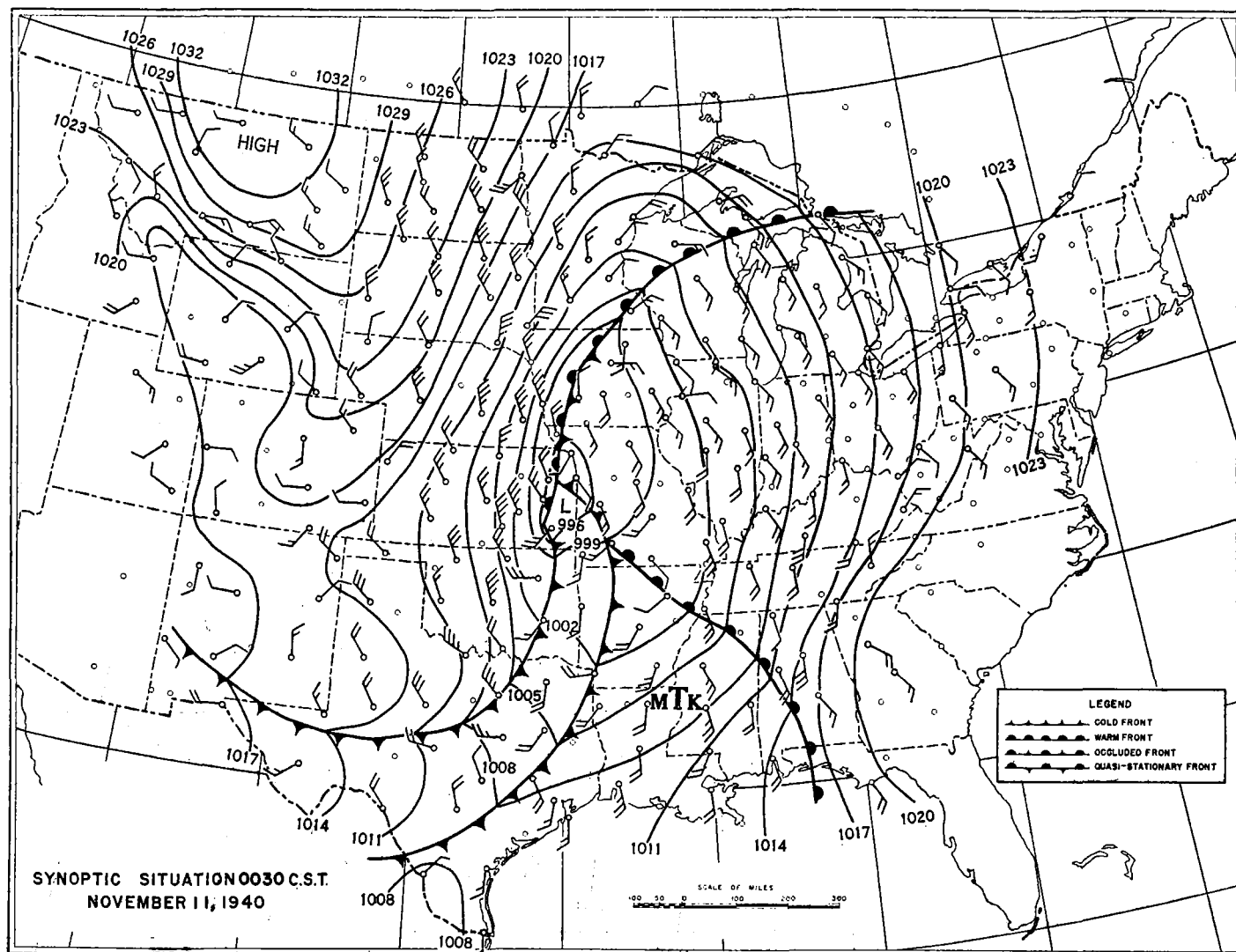


FIGURE 4.—Synoptic situation 0030 C. S. T., November 11, 1940.

TABLE 1.—Shows the hourly wind data at the Weather Bureau's University Observatory on Nov. 11, 1940

Hours	Prevailing direction	Average velocity	Maximum velocity ¹	Dines extreme ²
12-1 a. m.	SE.	13	-----	-----
1-2 a. m.	SE.	14	-----	-----
2-3 a. m.	SE.	14	-----	-----
3-4 a. m.	SE.	16	-----	26
4-5 a. m.	SE.	17	-----	27
5-6 a. m.	SE.	17	SE. 21	-----
6-7 a. m.	SE.	13	-----	-----
7-8 a. m.	SE.	16	SE. 21	29
8-9 a. m.	SE.	21	SE. 26	39
9-10 a. m.	SW.	21	SW. 26	38
10-11 a. m.	SW.	21	SW. 26	35
11-12 a. m.	SW.	25	SW. 40	58
12-1 p. m.	SW.	29	SW. 38	59
1-2 p. m.	SW.	34	SW. 40	60
2-3 p. m.	SW.	35	SW. 42	64
3-4 p. m.	SW.	35	SW. 41	65
4-5 p. m.	SW.	34	SW. 39	64
5-6 p. m.	SW.	35	SW. 39	62
6-7 p. m.	SW.	33	SW. 41	51
7-8 p. m.	SW.	32	SW. 38	55
8-9 p. m.	SW.	33	SW. 36	59
9-10 p. m.	SW.	29	SW. 36	54
10-11 p. m.	SW.	28	SW. 34	50
11-12 p. m.	SW.	29	SW. 40	55

¹ Maximum velocity for 5 minutes when more than 20 miles an hour.² Dines extreme values represent gust velocities.

The temperature at Chicago reached a high mark of 63° F. in the late forenoon of the 11th and dropped to 20° F. at midnight.

Figure 9 shows the barograph trace at the Chicago office of the Weather Bureau on the 14th floor of the United States courthouse. The lowest pressure, corrected, was 28.23 inches, which reduced to sea level is 29.09 inches. Due to the rapid deepening of the cyclone and the closeness of the second front, there was only a very slight rise in pressure following the passage of the first of the two fronts.

Further progress of the storm.—At 1830 C. S. T. the storm was centered over Lake Superior a short distance west of Houghton, Mich., where the sea-level barometer reading was 28.57 in., the lowest reported by any station in the United States during the progress of this cyclone. After the center of the disturbance had passed north of LaCrosse, the pressure continued to fall as a result of the deepening accompanying the occlusion process that was taking place, and reached a minimum of 28.72 inches, the lowest sea level pressure ever recorded at that station. Duluth, which was west of the path of the center, also

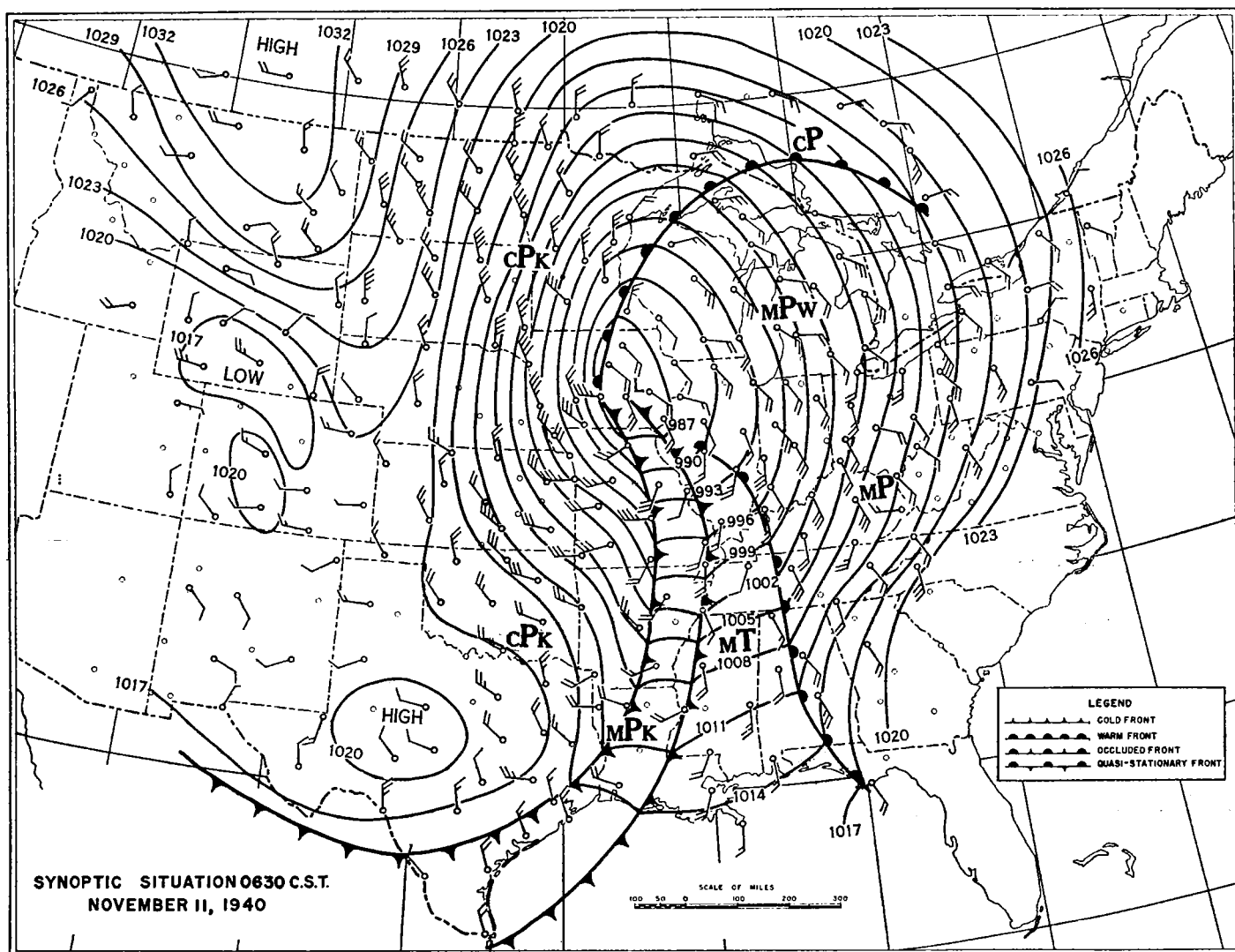


FIGURE 5.—Synoptic situation 0630 C. S. T., November 11, 1940.

had the lowest pressure of record when the barometer reading dipped to 28.66 inches at 5:30 p. m. The cold fronts, the first of which is now shown as occluded, were over Lake Erie as indicated in figure 7. Gales reached extreme velocities of 80 m. p. h. at Grand Rapids, 67 at Muskegon, 61 at Alpena, 50 at Lansing, and 49 at Escanaba, according to Weather Bureau reports, these being the highest winds of record at those stations. In general, stations east of the Mississippi River reported a shift from SE. to S. when the first front passed and a further shift to SW. when the second front arrived, with no further shift in direction later.

During the night of November 11-12, the cyclone continued its north-northeastward movement into Ontario with the same or slightly increased intensity.

Table 2 lists the lowest barometer reading and the

maximum wind velocity for 5 minutes at a number of stations affected by the storm. All of these readings occurred between noon and midnight of November 11.

Precipitation area.—During the day of November 11, moderate to heavy rain fell over the Mississippi Valley, many stations reporting between two and three inches. Snow fell over sections west of the storm path, and was both heavy and prolonged in eastern and central portions of Minnesota and in some sections of western Iowa. At Minneapolis the 24-hour snowfall was 16.2 inches on the 11-12, the heaviest ever recorded. Other stations in Minnesota reported from 22 to 22.6 inches. In northwestern Iowa the heaviest reported was 17 inches. (See *Climatological Data*, Iowa and Minnesota sections, November 1940.)

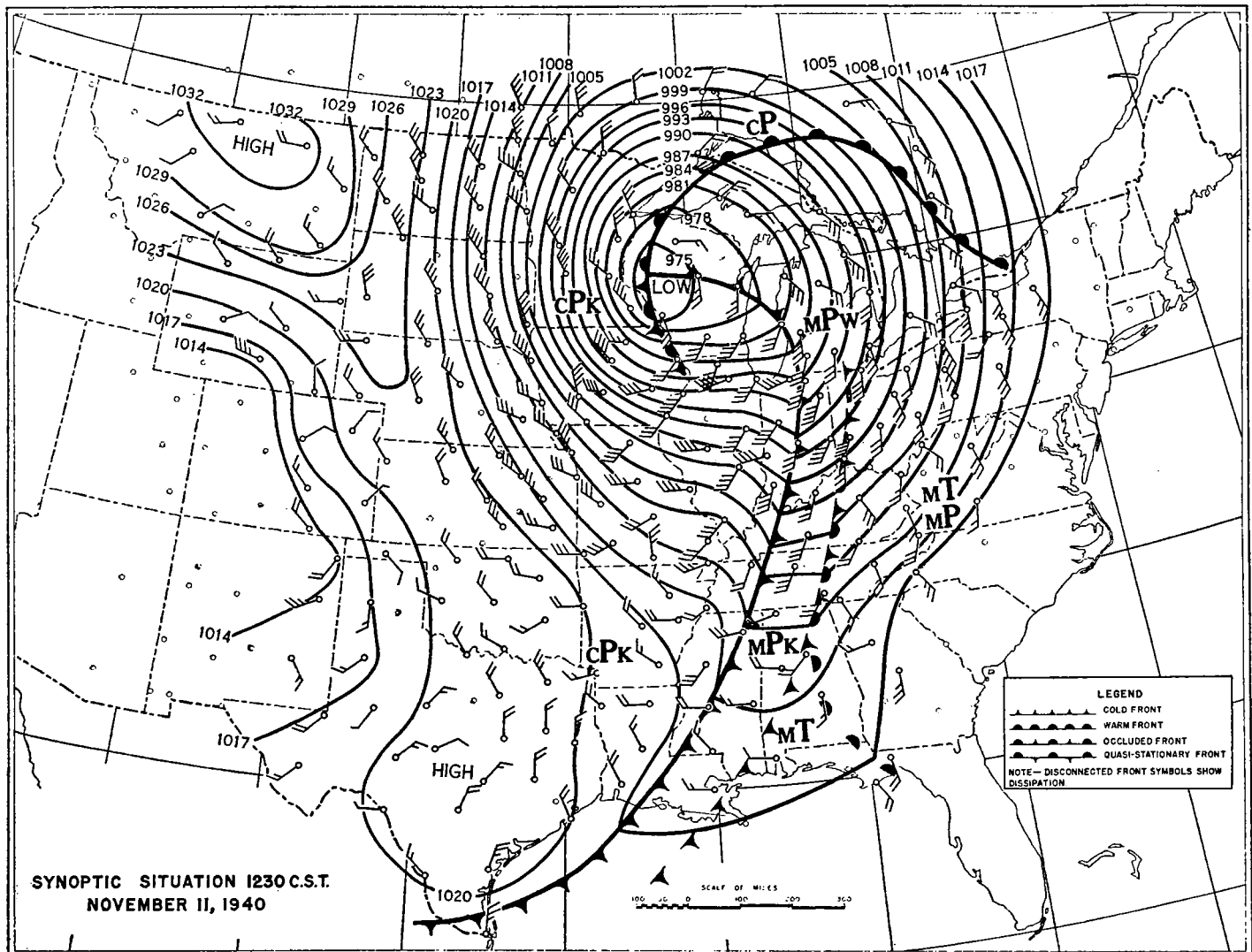


FIGURE 6.—Synoptic situation 1230 C. S. T., November 11, 1940.

TABLE 2.—Lowest pressure and maximum wind, in inches and miles an hour respectively, reached on Nov. 11, 1940

Station	Lowest pressure (sea-level)	Maximum wind (5 minutes)
	<i>Inches</i>	<i>Miles</i>
Illinois:		
Cairo.....	29.45	SW. 37
Chicago.....	29.09	SW. 42
Peoria.....	29.15	SW. 29
Springfield.....	29.23	SW. 46
Indiana:		
Fort Wayne.....	29.27	SW. 53
Indianapolis.....	29.36	SW. 37
Terre Haute.....	29.34	SW. 47
Evansville.....	29.45	SW. 47
Iowa:		
Charles City.....	28.92	W. 34
Davenport.....	29.09	SW. 38
Des Moines.....	29.06	NW. 36
Dubuque.....	28.99	SW. 22
Keokuk.....	29.15	W. 41
Sioux City.....	29.54	NW. 43
Michigan:		
Alpena.....	29.06	SW. 47
Detroit.....	29.32	SW. 45
Escanaba.....	28.77	S. 43

TABLE 2.—Lowest pressure and maximum wind, in inches and miles an hour respectively, reached on Nov. 11, 1940—Continued

Station	Lowest pressure (sea-level)	Maximum wind (5 minutes)
	<i>Inches</i>	<i>Miles</i>
Michigan—Continued.		
Grand Rapids.....	29.10	SW. 65
Lansing.....	29.16	SW. 41
Marquette.....	28.67	S. 33
Saulte Ste. Marie.....	28.95	SW. 34
Minnesota:		
Duluth.....	28.66	NW. 52
Minneapolis.....	28.93	W. 38
Ohio:		
Cleveland.....	29.45	SW. 59
Columbus.....	29.53	SW. 53
Dayton.....	29.53	S. 47
Sandusky.....	29.40	SW. 42
Toledo.....	29.35	W. 38
Wisconsin:		
Green Bay.....	28.80	S. 47
La Crosse.....	28.72	SW. 24
Madison.....	28.92	SW. 40
Milwaukee.....	28.94	SW. 54

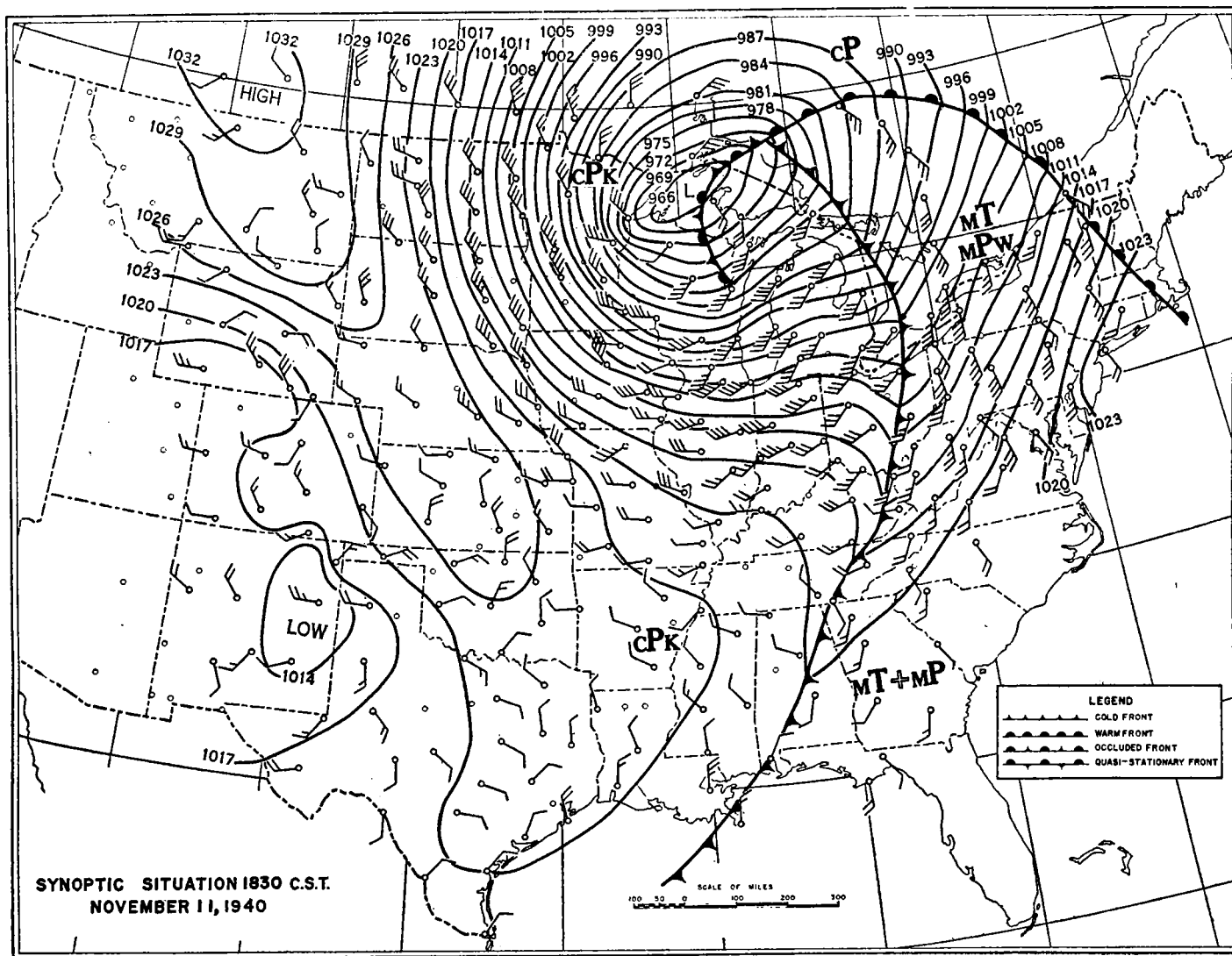


FIGURE 7.—Synoptic situation 1830 C. S. T., November 11, 1940.

WEATHER BUREAU

CROSS SECTION THROUGH THE ATMOSPHERE

NOV. 11 1940

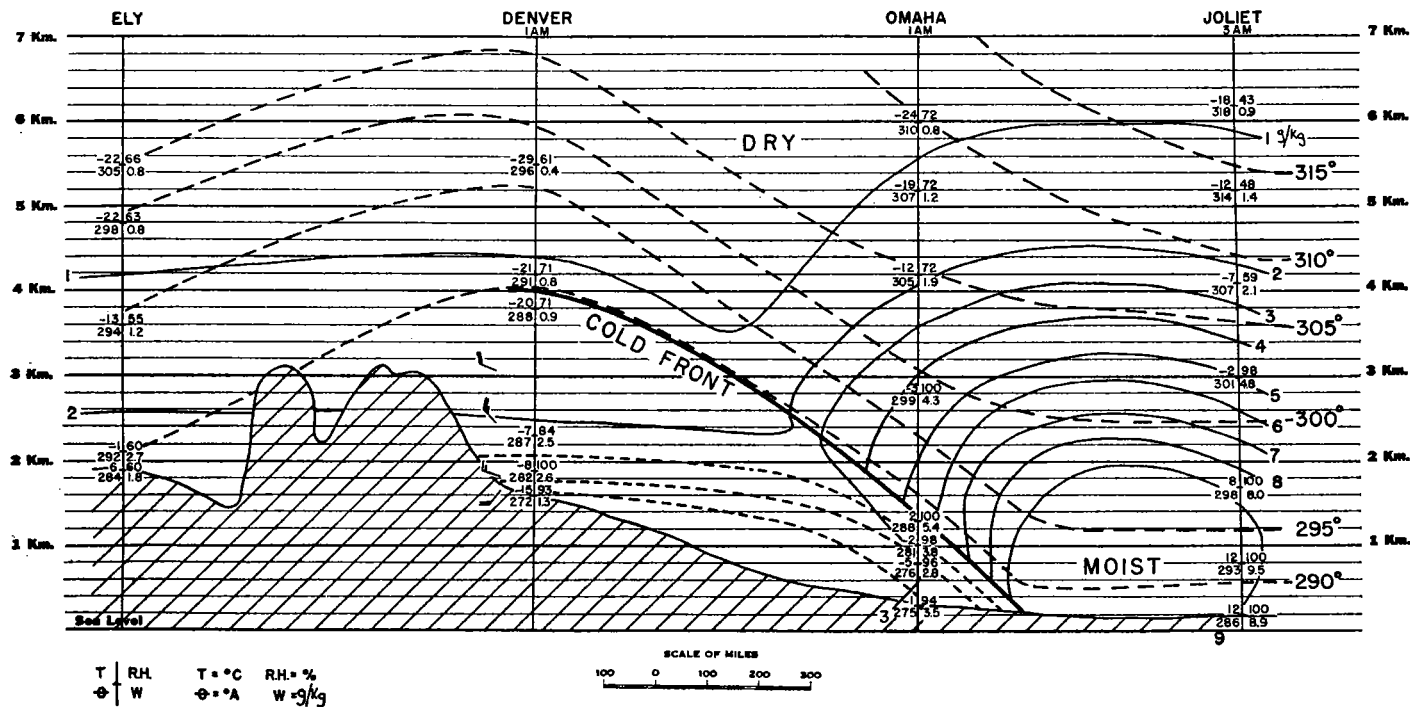


FIGURE 8.—Cross-section through the atmosphere on early morning of November 11, 1940.

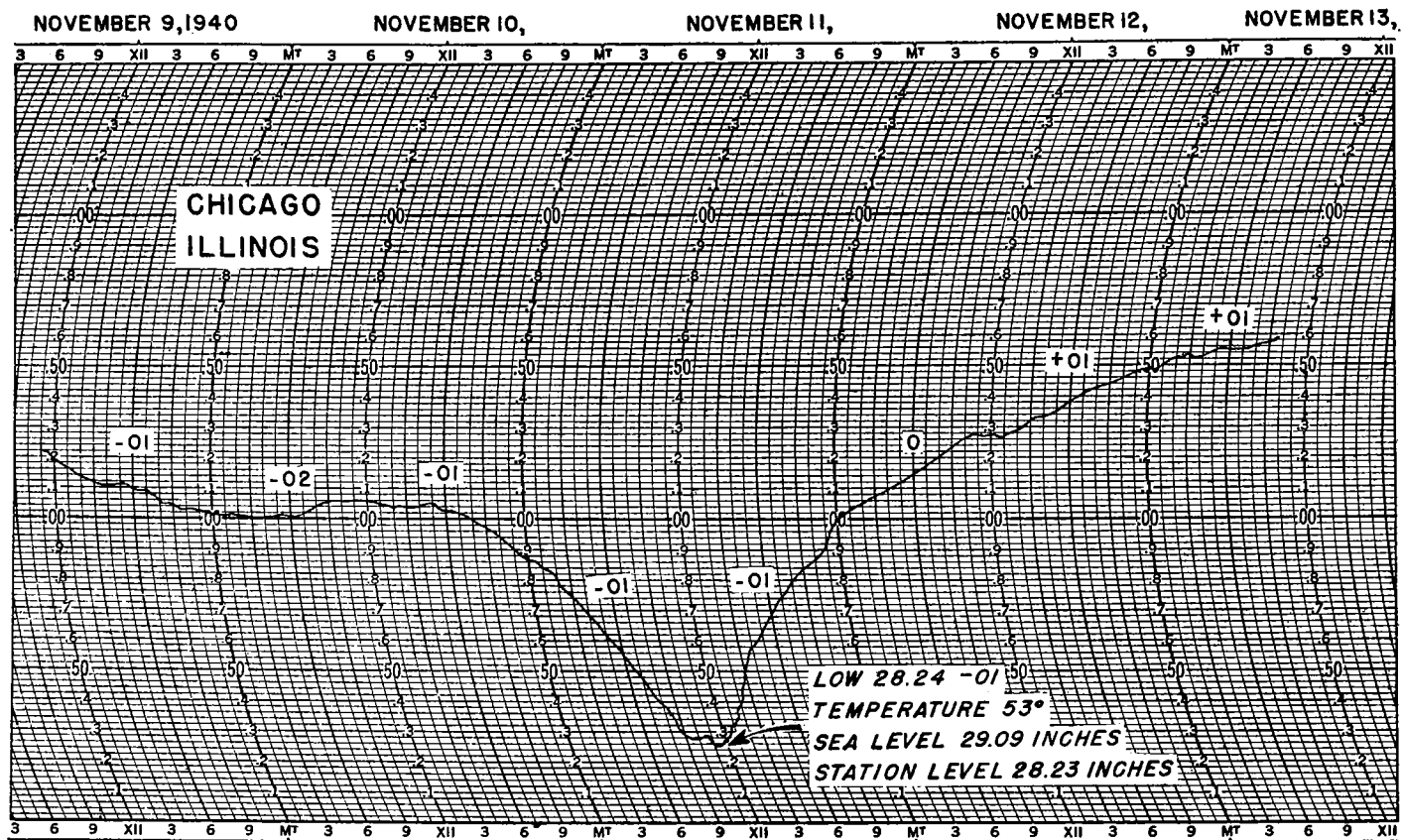


FIGURE 9.—Copy of barograph trace at Chicago, November 9-13, 1940.

Intensification of the storm.—The extremely rapid intensification of this storm in the 24 hours following 1830 C. S. T., November 10, is noteworthy. During this period the pressure at the center decreased at least 28.7 millibars, or 0.85 inch. In the same interval, the center moved approximately 825 miles, or at an average speed of about 35 miles an hour. Such simultaneous rapid deepening and fast movement of extratropical cyclones over a land surface are comparatively rare. As to the source of energy which contributed to the pronounced cyclogenesis, both latent heat liberated in the condensation process and potential energy of mass distribution were undoubtedly very important. Attention has already been called to the heavy and widespread precipitation. While amounts were locally between 2 and 3 inches, hundreds of thousands of square miles received more than 1 inch. The total area that had rain or snow extended from the Plains States to the Appalachian Mountains. Mention has already been made of the air mass distribution on the morning of November 11; it should be emphasized, however, that the contrast in the thermodynamic properties of the tropical air over the Mississippi Valley and the polar air over the Plains States was exceedingly great. The tropical air was fresh from its source region, and the deep polar air mass was very cold and comparatively dry. As the cold air started spreading southward and southeastward around the cyclone center, replacing warmer and lighter air at lower levels, the lowering of the center of gravity of the cold air mass, and hence loss of potential energy, was responsible for an increase in the kinetic energy of the system. This process was in operation throughout the day as the cold air spread rapidly eastward.

Table 3 gives pressure data computed from the radiosonde observations of November 10 and 11. In this table, Δp is the change in pressure, in millibars, between the two observations; $\frac{\Delta p}{p}$ denotes the percentage of change in pressure at the various levels. Some interesting conclusions may be drawn from these figures. First, at Joliet, since the greatest pressure fall was at the surface and was limited mostly to the lower 3 km. we may assume that the decrease was due to advection of warmer air in the lower troposphere. Keeping in mind that the pressure at any level is the weight of the air column above that elevation and noting that at 10 km. the pressure has increased, it appears probable that there had been convergence in the upper troposphere. Second, we note that the greatest pressure fall at Omaha was at 3 km., though there was an appreciable decrease at 5 and 10 km. This suggests that considerable divergence had occurred in the 24-hour period, since there was no advection of warmer air. Third, at Bismarck, a rise of 5 millibars in surface pressure was offset by slight decreases at 3, 5, and 10 km. Advection of colder and drier air in the lower troposphere was sufficient not only to offset the decreases at higher levels but also to give an appreciable rise in surface or total pressure.

TABLE 3.—Changes in pressure, and percentages of change, from Nov. 10 to Nov. 11, 1940

	Joliet		Omaha		Bismarck	
	Δp	$\frac{\Delta p}{p}$	Δp	$\frac{\Delta p}{p}$	Δp	$\frac{\Delta p}{p}$
Surface.....	-9	0.91	-10	1.03	+5	0.52
3 km.....	-2	.29	-12	1.73	-2	.29
5 km.....	-1	.18	-6	1.12	-3	.57
10 km.....	+3	1.12	-4	1.52	-2	.79

While pressure changes and percentages of change as given are subject to the usual inaccuracies of measurement, which are of the same order of magnitude as the smaller changes, it appears that the larger changes are significant.

Only a closer network of radiosonde stations and more frequent observations during the development and progress of such storms as the one under discussion will furnish the data necessary for an adequate analysis and dynamical study of upper air conditions at such critical stages.

DESTRUCTION WROUGHT BY STORM

Because of the difficulty in estimating tangible losses and the impossibility of adequately describing the intangible aspects of destruction, the full import of the storm for the economy of the states affected cannot be told. It appears appropriate, however, to attempt some description and tabulation of the losses sustained, both in life and property, as a direct result of this phenomenal storm. Because of the severity of the gales on the Great Lakes and the resultant effects on shipping, the losses will be treated separately for the land and water areas.

Losses by States.—Table 4 gives in summary form for each State such information on losses as appears in the various sections of *Climatological Data* for November 1940.

TABLE 4.—Summary of losses by States

State	Deaths	Livestock and poultry	Other losses	Estimated loss
Iowa.....	7	1,500 cattle 2,000 sheep. 200 hogs. 150,000 turkeys.	Corn in fields, apple orchards, communication lines, automobile radiators frozen, etc.	(?).
Illinois.....	13		Communication and power lines, buildings, trees, signs, etc.	\$2,000,000 plus.
Indiana.....	1		Communication lines, trees, radio mast at WIND, etc.	\$200,000.
Kentucky.....			Minor damage to wire systems, trees uprooted, signs blown down, etc.	(?).
Louisiana.....			Property damage due to tornado at Napoleonville.	\$10,000.
Michigan.....	4		Buildings, trees, power and communication lines, sign boards, radio mast at WJ.R.	"Several millions."
Minnesota.....	49	Thousands of turkeys and game birds; much livestock.	Communication and power lines, highways, trees, automobiles, etc.	\$1,500,000 plus.
Missouri.....			Minor damage to roofs, trees, window glass, etc.	(?).
Nebraska.....		Thousands of turkeys; some livestock.	Fruit and shade trees.	(?).
New York.....	1		Considerable damage to telegraph and power lines, signs, windows, trees, etc.	(?).
Ohio.....			Considerable damage to roofs, trees, windows, utility lines.	(?).
South Dakota.....		Some livestock.	Highways blocked.	(?).
Tennessee.....			Minor damage central and western counties except more severe in Crockett and Weakley counties where tornado occurred.	\$160,000
Texas.....			Local storm at Huntsville.	\$50,000.
Wisconsin.....	13	Some livestock considerable number of turkeys.	Widespread damage to poles and wires, etc.	\$300,000.

In Kansas a severe cold wave on November 10-11 caused the coldest weather ever experienced so early in the season over practically the entire State.

Freezing temperature and frost were general over Oklahoma; and killing frost occurred in the Texas Panhandle on the morning of the 11th.

Losses on the Great Lakes.—The storm of November 11, 1940, was one of the most severe of record affecting the Upper Great Lakes.

Lake Michigan.—Greatest losses were on Lake Michigan, which felt the full fury of the southwest gales. Three steamers were sunk, a number of others were grounded, and several smaller boats were lost. Possibly because early in the day the wind was from the southeast and increasing, some of the captains navigated their vessels near the east shore of Lake Michigan; the sudden shift to southwest gales later proved disastrous, as the steamers were practically helpless because they could not run before the storm nor withstand the battering which would result from heading into the gale and high waves. The three freighters that foundered all sank off Pentwater, near Ludington, Mich., with loss of life as follows: *William B. Davock*, 33; *Anna C. Minch*, 24; *Novadoc*, 2.

Other drownings occurred when the fishing tugs *Indian* and *Richard H.* and the motor cruiser *Nancy Jane*, with a total of 10 persons aboard, were lost on the southern end of Lake Michigan.

Ships reported as driven ashore or on reefs, in addition to many smaller boats, were: *Sinaloa* at Escanaba; *City of Flint* at Ludington; *Conneaut* on north shore of Straits of Mackinac; *Frank J. Peterson* on St. Helena Island (reported as abandoned on November 21).

Other vessels, including the *Joseph Block* and the *New Haven Socony*, were badly battered but eventually made port.

The effect of the sustained southwest gale on the water level of Lake Michigan is indicated by reports of a drop of 4.8 feet at Chicago, and a rise of 4 to 4.5 feet at Beaver Island. A lowering of water in the Fox River by about 5 feet, the result of south and southwest winds, forced paper mills and a power plant to suspend operations at Green Bay, Wisconsin.

Lake Superior.—On Lake Superior comparatively little damage occurred, and no loss of life was reported though two fishermen may have perished in Whitefish Bay. The shifting gales on the extreme western end of the lake were responsible for the breaking loose and the plunging overboard of a number of automobiles from the deck of the steamer *Crescent City*. Captain Harold B. McCool, master of the vessel, reported that the gale was the worst he had experienced on the Great Lakes in more than 40 years service, and is quoted as saying "In my opinion, the storm was even more severe than the disastrous storm during the Fall of 1913" (November 1913). The freighter *Sparta* was lost after grounding on rocks 5 miles east of

Munising on the night of November 12, but no loss of life occurred.

Lake Huron.—Lake Huron traffic sustained losses small in comparison to those that might have resulted if the severe gales had been on-shore instead of off-shore. Damage was mostly to small craft, and no fatalities were reported. Fishing boats made shelter but losses to nets were considerable.

The Alpena Weather Bureau office supplied the following graphic account by the master of the steamer *Wyandotte*:

The *Wyandotte*, a large freighter carrying 2,700 tons of coal and bound for Alpena, was off Saginaw Bay at the height of the storm. The sea broke over her decks in solid sheets. The storm was of such fury that water actually poured into her smoke stack at times. Normally an 11-mile-an-hour vessel, the freighter in some places could make no better headway than 2-3 miles an hour.

The lake level dropped about 2 feet at Alpena; and at Saginaw Bay the water receded a mile in places, lowering the water in the Saginaw River as much as 8 feet at its mouth, and 9 feet 15 miles upstream at the Consumers Power plant which had to be shut down. At Bay City the receding water caused water supply intake pipes to be exposed, thus necessitating the pumping of water from reservoirs.

Lower lakes.—Lakes Erie and Ontario, though lashed by gales, were far enough from the storm center to escape with only minor damage to shipping. The water level in the lower Detroit River was lowered about 4.5 feet by the strong winds on Lake Erie.

Though the loss of life on the Great Lakes in this storm was much smaller than in the case of the November 1913 disaster, nevertheless, the November 11, 1940, storm must be considered as one of the most devastating ever to sweep the Upper Great Lakes Region.

CONCLUSION

It has been pointed out that the storm described herein resulted in much loss of life and property because of its occurrence on a holiday immediately following the usual week-end vacation period. This is true, unfortunately, since the storm caught many hunters away from home and adequate shelter; and many automobiles were marooned on the highways in some sections. Apart from these and other circumstances that contributed to the appalling losses sustained, it remains a fact that the Armistice Day storm of 1940 was one of the very worst, considering the intensity of the meteorological factors and the effects thereof, ever to sweep over this vast area of the Midwest section of the United States.

NOTES AND REVIEWS

Andrew M. Hamrick and Howard H. Martin. *Fifty Years' Weather in Kansas City, Mo., 1889-1938.* MONTHLY WEATHER REVIEW SUPPLEMENT No. 44, 1941. 53 pp.

This publication is devoted to detailed climatic statistics compiled from the records of the Weather Bureau station at Kansas City. The data are presented in 34 graphs accompanied by a brief descriptive text, and in 108 tables that occupy 34 pages.

William V. Turnage and T. D. Mallery. *An Analysis of Rainfall in the Sonoran Desert and Adjacent Territory.* Carnegie Institution of Washington Publication 529. 1941. 45 pp., illus.

The authors summarize some of the results of a study of rainfall data obtained at a considerable number of stations in the arid Southwest of the United States.

The periods of record range from 10 years or less for the seasonal rainfall stations which were maintained in unsettled localities by the Desert Laboratory of the Carnegie Institution, up to 50 years or more for some of the Weather Bureau stations.

There are two well-defined rainy seasons in the region, with essentially different types of precipitation. The rainfall of each season is discussed with reference to the effects of topographical relief, elevation, and slope exposure on the areal distribution. The variability over small areas is also investigated, and several other topics briefly touched.

It is concluded that "little essential advance can be made in the investigation of rainfall by continuation of readings at arbitrarily selected localities which happen to be centers of population. Intensive study of rainfall for a relatively short period at carefully selected critical localities would advance our knowledge far more than the continuation for many years of routine readings at sporadically located stations. Study of rainfall patterns in small areas and further study of topographic influences, in conjunction with investigation of run-off in relation to the incidence and intensity of rain, and of soil moisture in different types of soil, should go far toward meeting the